SELF-TEST

A. Multiple Choice:

1. The heat of formation of liquid water refers to the equation
   a. $2\,H_2\,(g) + O_2\,(g) \rightarrow 2\,H_2O\,(\ell)$
   b. $2\,H\,(g) + O\,(g) \rightarrow H_2O\,(\ell)$
   c. $H^+\,(aq) + OH^-\,(aq) \rightarrow H_2O\,(\ell)$
   d. $H_2\,(\ell) + \frac{1}{2}\,O_2\,(g) \rightarrow H_2O\,(\ell)$
   e. None of these

2. When the heat content of the reactants in a reaction is greater than the heat content of the products
   a. heat is absorbed and the reaction is exothermic.
   b. heat is evolved and the reaction is exothermic.
   c. heat is absorbed and the reaction is endothermic.
   d. heat is evolved and the reaction is endothermic.
   e. none of the above applies.

3. When 2.0 g of a certain solid are added to 50.0 g of water in a calorimeter, the temperature drops from 25.0 to 22.6°C. This means that
   a. q_{H_2O} is positive and the reaction is endothermic.
   b. q_{H_2O} is positive and the reaction is exothermic.
   c. q_{H_2O} is negative and the reaction is endothermic.
   d. q_{H_2O} is negative and the reaction is exothermic.

4. Given that

   $$2\,Fe_2O_3\,(s) \rightarrow 4\,Fe\,(s) + 3\,O_2\,(g) \qquad \Delta H^\circ = +393.0\,kJ$$

   then ΔH_f° for Fe_2O_3 is

   a. +196.5 kJ **b.** –196.5 kJ **c.** +393.0 kJ **d.** –393.0 kJ

5. Which of the following data is not required for calculating ΔH of solution for one mole of sample in a coffee cup calorimeter?
   a. temperature change of the water **b.** mass of the water
   c. atmospheric pressure **d.** mass of the sample
   e. specific heat of the water

6. In a reaction, $\Delta H = +312$ kJ. How many of the following statements are true?

   — The products have a lower enthalpy than the reactants.
   — The enthalpy change for the reverse reaction is –312 kJ.
   — The reaction absorbs heat from the surroundings.
   — The reverse reaction is endothermic.

   a. 0 **b.** 1 **c.** 2 **d.** 3 **e.** 4

7. Which of the following are true about ΔH of a reaction?

   (1) ΔH for the overall reaction does not depend on the number of steps required to complete the reaction.
   (2) ΔH is related to the heats of formation of the reactants and products.
   (3) ΔH is independent of the amounts of products or reactants.
   (4) ΔH has the same sign regardless of the direction of the reaction.

   a. (2) **b.** (1),(2) **c.** (2),(3) **d.** (2),(4) **e.** (1),(2),(3),(4)

8. The bond energy for the H—Cl bond is equal to
   a. ΔH when one mole of H—Cl bonds is formed from gaseous atoms.
   b. the heat of formation of H—Cl.
   c. ΔH for the process $H(g) + Cl(g) \rightarrow HCl(g)$.
   d. ΔH for the process $H_2(g) + Cl_2(g) \rightarrow 2\,HCl(g)$.
   e. none of these.

9. The standard heat of formation of HF is –268.6 kJ/mol. Which of the following reactions represents – B.E. for HF? (B.E. stands for bond energy)
   a. $H(g) + F(g) \rightarrow HF(g)$
   b. $2\,H(g) + 2\,F(g) \rightarrow 2\,HF(g)$
   c. $\frac{1}{2}\,H_2(g) + \frac{1}{2}\,F_2(g) \rightarrow HF(g)$
   d. $H_2(g) + F_2(g) \rightarrow 2\,HF(g)$

10. Given $\Delta H° = -635.1$ kJ for the reaction

$$Ca(s) + \tfrac{1}{2}\,O_2(g) \rightarrow CaO(s)$$

    What would you expect to happen if the reaction were allowed to proceed at 1 atm in a heavily insulated container so that no heat flow could occur between the reaction mixture and the surroundings?
    a. No reaction would occur.
    b. The temperature of the reaction mixture would rise.
    c. The temperature of the reaction mixture would fall.
    d. Cannot tell because there is not enough information given.

B. Answer the questions below, using **LT** (for *less than*), **GT** (for *greater than*), **EQ** (for *equal to*), or **MI** (for *more information required* in the blanks provided.

_____ **1.** The energy required to break a C=C bond (1) the energy required to break a C–C bond.

_____ **2.** Consider two metals A and B ($c_A > c_B$) of equal mass and at the same temperature. Consider further two beakers X and Y each with 100 g of water at 25°C. Metal A is added to beaker X, while metal B is added to beaker Y. The temperature of the water in both beakers rises. The temperature of the water in beaker X (2) the water temperature in beaker Y.

_____ **3.** In an endothermic reaction, $q_{reactants}$ _(3)_ $q_{products}$.

_____ **4.** For the reaction

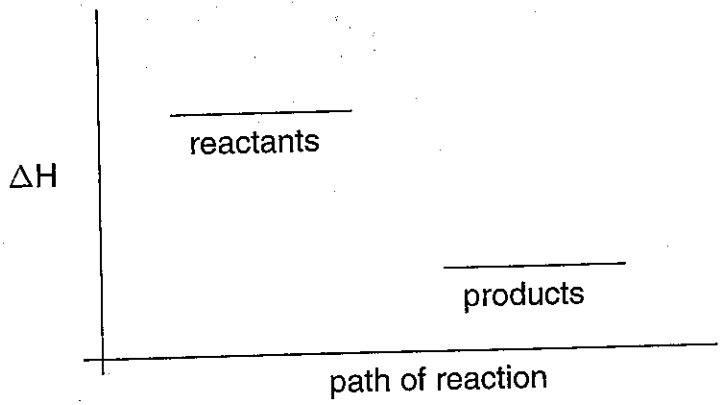
$$H_2 + O_2 \rightarrow H_2O$$

$\Delta H°$ is _(4)_ to the heat of formation of H_2O (ℓ).

_____ **5.** The heat of solution for compound Z is −100 kJ/mol. When Z is dissolved in water at 25°C, the temperature of the resulting solution is _(3)_ 25°C.

C. True or False

Consider a reaction with the following energy diagram.



For this reaction

_____ **1.** the temperature of the surroundings increases.

_____ **2.** $q_{reaction} > 0$ at constant pressure.

_____ **3.** it is an exothermic reaction.

_____ **4.** a change in the mass of reactants changes the sign for ΔH.

_____ **5.** the enthalpy of products is larger than the enthalpy of reactants.

D. Problems

Consider the reaction between one mole of solid silver sulfide ($\Delta H_f^\circ = -31.8$ kJ/mol) and liquid water, producing silver metal, hydrogen sulfide (H_2S) gas, and oxygen gas.

1. Write the thermochemical equation for this reaction using Table 8.3 of your text.

2. Is the reaction exothermic or endothermic?

3. How much heat is required to produce 10.00 g of silver?

4. If only 200.0 kJ of heat are supplied and 400.0 g of silver sulfide are used as a starting reagent (an excess of water is available), how many grams of silver sulfide will remain unreacted?

Consider the reaction between two moles of lithium metal and water to produce solid lithium hydroxide and hydrogen gas.

5. Write an equation for the reaction.

6. If the reaction is exothermic and evolves 402.4 kJ of heat, write the thermochemical equation.

7. Calculate ΔH_f° for LiOH.

8. Calculate the final temperature of the water if the reaction was done in a bomb calorimeter (heat capacity = 6.03×10^3 J/°C) at 25.00°C.

ANSWERS

Exercises:

(E1) specific heat = 0.359 J/g·°C; heat capacity = 2.15 J/°C

(E2) $q_{reaction} = -9.745$ kJ; $q_{H_2O} = 9.745$ kJ; $t_{final} = 33.08°C$

(E3) 5.90 kJ/°C

(E4) $NH_4NO_3\,(s) \rightarrow NH_4^+\,(aq) + NO_3^-\,(aq) \quad \Delta H > 0$

(E5) a. $CaSO_4\,(s) + CO_2\,(g) \rightarrow SO_3\,(g) + CaCO_3\,(s) \quad \Delta H° = 223.8$ kJ; **b.** 2.166 g

(E6) (1) $I_2\,(g) + H_2\,(g) \rightarrow 2\,HI\,(g) \quad \Delta H° = 51.8$ kJ; **(2)** −1.65 kJ; **(3)** evolved

(E7) $\Delta H° = -1776$ kJ

(E8) −10.52 kJ

(E9) $C_2H_5OH\,(\ell) + 3\,O_2\,(g) \rightarrow 2\,CO_2\,(g) + 3\,H_2O\,(g) \quad \Delta H° = -1235$ kJ

(E10) $2\,CH_3OH\,(\ell) + 3\,O_2\,(g) \rightarrow 2\,CO_2\,(g) + 4\,H_2O\,(g) \quad \Delta H° = -1277$ kJ

(E11) −300.0 kJ/mol **(E12)** −222 kJ **(E13)** 612 J

(E14) −153 kJ, done by the system

Self-Test

A. Multiple Choice:

1. e	**2.** b	**3.** c	**4.** b	**5.** c
6. c	**7.** b	**8.** e	**9.** a	**10.** b

B. Greater than, Less than, or Equal to:

1. GT	**2.** GT	**3.** LT	**4.** MI	**5.** LT

C. True or False:

1. T	**2.** F	**3.** T	**4.** F	**5.** F

D. Problems:

1. $Ag_2S\,(s) + H_2O\,(\ell) \rightarrow 2\,Ag\,(s) + H_2S\,(g) + \frac{1}{2}\,O_2\,(g) \quad \Delta H° = 297.0$ kJ

2. endothermic

3. 13.76 kJ

4. 233.1 g

5. $2\,Li\,(s) + 2\,H_2O\,(\ell) \rightarrow 2\,LiOH\,(s) + H_2\,(g)$

6. $2\,Li\,(s) + 2\,H_2O\,(\ell) \rightarrow 2\,LiOH\,(s) + H_2\,(g) \quad \Delta H° = -402.4$ kJ

7. −487.0 kJ

8. 91.7 °C